APPENDIX B. FUNCTION AND SCENARIO SELECTION

FUNCTION SELECTION

The following paragraphs summarize the procedure and results of each analysis used for function selection, initially for the private vehicle operations and then for the commercial vehicle operations.

Functional Characteristics Included in the Private Vehicle Task Analysis

A casual examination of the functional characteristics suggest that some may be more critical than others for overall system operation. In addition, it is obvious that certain combinations of ATIS functional characteristics may interact more strongly than others. A detailed examination of the information flows ensures that the scenarios used for the task analysis include important functional characteristics and meaningful groups of functional characteristics. This detailed examination shows which functions are most central to ATIS/CVO and which functional characteristics form highly coupled groups, based on the information flows that link them.

This analysis depends on identifying the information flows to and from each functional characteristic. The functional characteristics and information flows can be considered as a network, with functional characteristics representing the nodes of the network and information flows representing the links between nodes (see figure 3). This network can also be considered as a matrix of input/output relations. Such a matrix of input/output relations (see table 24) was created to summarize the information flows between functions.

To better understand what is meant by input/output relations, it is necessary to define a frame of reference for these inputs/outputs. In this particular analysis, the frame of reference used is the ATIS itself. In other words, an "input" is defined as information and data coming *to* the function, while an "output" is defined as information and data coming *from,* or produced by, the function. Thus, the ATIS function acts as a transfer function, transforming information and data from inputs to outputs.

In this matrix, an entry was made each time a given function served as either an input or output to another function. In other words, each time there is a "1" in the matrix, it indicates a link between the two functions. The first row and the first column of numbers represent each one of the functions, and the matrix reads as follows: Function 5.1 provides information to functions 5.2, 5.3, 5.6, 6.1, 6.3, 7.1, 7.2, and 8.2. Similarly, the first column reads as follows: Functions 5.7, 6.2, and 8.2 provide information to function 5.1. In other words, functional characteristics listed horizontally receive input from the functional characteristics listed vertically. To make it easier to understand, figure 25 provides a graphical representation of this first row and column, illustrating the functions that are considered inputs and the ones that are considered outputs.

Table 24. Information flows between functions for private vehicle operations.

		OUTPUTS																			
		IRANS							IMSIS				ISIS			IVSAWS					
	Function	5.1	5.2	5.3	5.4	5.5	5.6	5.7	6.1	6.2	6.3	6.4	7.1	7.2	7.3	8.1	8.2	8.3	8.4	8.5	TOTAL
INPUTS IRANS	5.1	0	1	1	0	0	1	0	1	0	1	0	1	1	0	0	1	0	0	0	8
	5.2	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3
	5.3	0	0	0	0	1	1	0	1	0	1	0	1	1	0	0	1	0	0	0	7
	5.4	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	1	0	0	0	5
	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5.6	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	5.7	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
IMSIS	6.1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	3
	6.2	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	6.3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ISIS	7.1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	7.2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IVSAWS	8.1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	4
	8.2	1	1	1	1	0	1	0	0	0	1	1	1	0	0	0	0	0	1	0	9
	8.3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2
	8.4	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	4
	8.5	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	5
TOTAL		3	5	5	6	3	8	0	3	2	8	3	5	3	0	2	3	1	3	0	
		11	8	12	6	3	10	3	6	6	9	3	7	4	0	6	12	3	7	5	INTERACTION TOTAL
		3	6	1.5	10.5	16.5	4	16.5	10.5	10.5	5	16.5	7.5	14	19	10.5	1.5	16.5	7.5	13	RANK

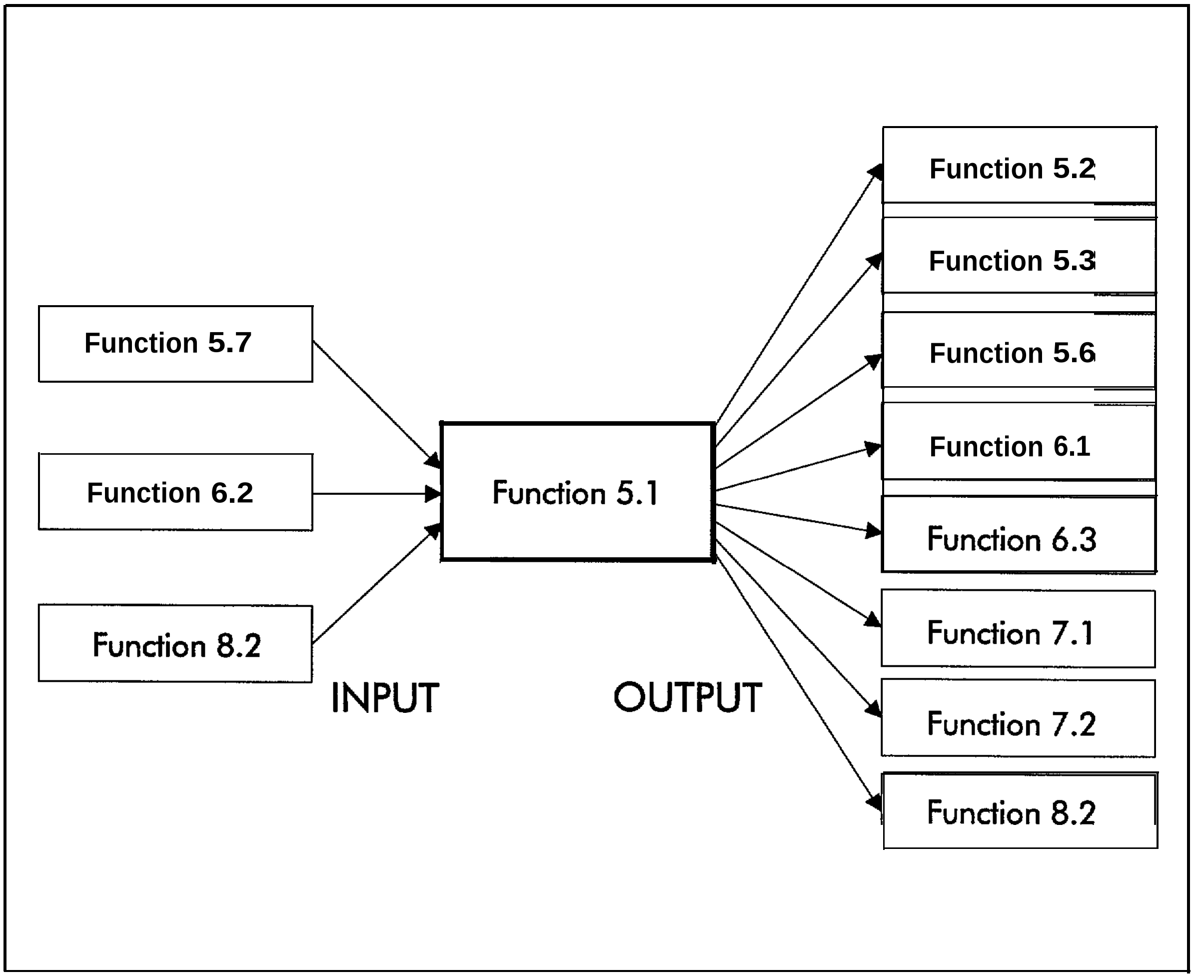

Figure 25. Graphical representation of the first row and column of the matrix (table 24).

Using this matrix of input/output relations, it is possible to calculate several measures of the importance of a functional characteristic and, as a consequence, determine its level of centrality in the system. Some of the measures calculated include a simple frequency count of the number of interactions between functions, while other measures of centrality are derived from network analysis techniques. The following paragraphs summarize the findings for each one of these analyses.

Frequency Count

A simple measure of the importance of a functional characteristic is the number of times it either receives from or provides information to other functions. The matrix depicted in table 24 offers the information necessary to calculate this frequency count. The bottom shaded row of table 24 indicates the total number of times a function receives information from other functions. This row shows that destination coordination (6.3) and route navigation (5.6) receive input from more functional characteristics than any other (eight times). Similarly, the right-most column shows the total number of inputs sent to other functional characteristics; for example, road condition information (8.2) provides information to more functional characteristics than any other (nine times).

By adding the row and column totals, it is possible to obtain a crude estimate of functional characteristic centrality. Those functional characteristics requiring the most inputs from other functions and providing the most outputs to other functional characteristics represent important nodes in the network of information flows that make up the ATIS. This analysis identifies pre-drive route and destination selection (5.3) and road condition information (8.2) as the two most central functions to an ATIS. The last row of table 24 shows the rank of each functional characteristic. Table 25 summarizes these results, showing the relative centrality of each functional characteristic.

Table 25. Rank ordering of the private functional characteristics.

RANK	FUNCTION		SYSTEM
1.5	5.3 8.2	Pre-drive and destination selection Road condition information	IRANS IVSAWS
3	5.1	Trip planning	IRANS
4	5.6	Route navigation	IRANS
5	6.3	Destination coordination	IMSIS
6	5.2	Multi-mode travel coordination and planning	IRANS
7.5	7.1 8.4	Guidance information Manual aid reauest	ISIS IVSAWS
10.5	5.4 6.1 6.2 8.1	Dynamic route selection Broadcast services/attractions Services/attractions directory Immediate hazard warning	IRANS IMSIS IMSIS IVSAWS
13	8.5	Vehicle condition monitoring	IVSAWS
14	7.2	Notification information	ISIS
16.5	5.5 5.7 6.4 8.3	Route guidance Automated toll collection Message transfer Automatic aid request	IRANS IRANS IMSIS IVSAWS
19	7.3	Regulatory information	ISIS

Network Analyses

In addition to the simple frequency count, other methods exist to determine the relative centrality of functional characteristics. These measures provide an added level of sophistication that may generate a more accurate estimate of centrality. The frequency count estimates centrality by independently considering the input and output of each functional characteristic. In many cases, this may not be an appropriate approach because a functional characteristic might be more central than another one. For instance, a functional characteristic that has several inputs coming into it has a heavier weight and should be considered more central than a functional characteristic that has only one input. For example, figure 26 shows that the function characteristic "A" has three inputs coming to it, while function characteristic "B" has only one input. In this instance, the output coming from "A" has a heavier weight than the one coming from "B" and should be given more importance when considering its implication in regard to function characteristic "C." To overcome the limits of the frequency count, a network analysis was conducted using the same matrix that generated the frequency counts.

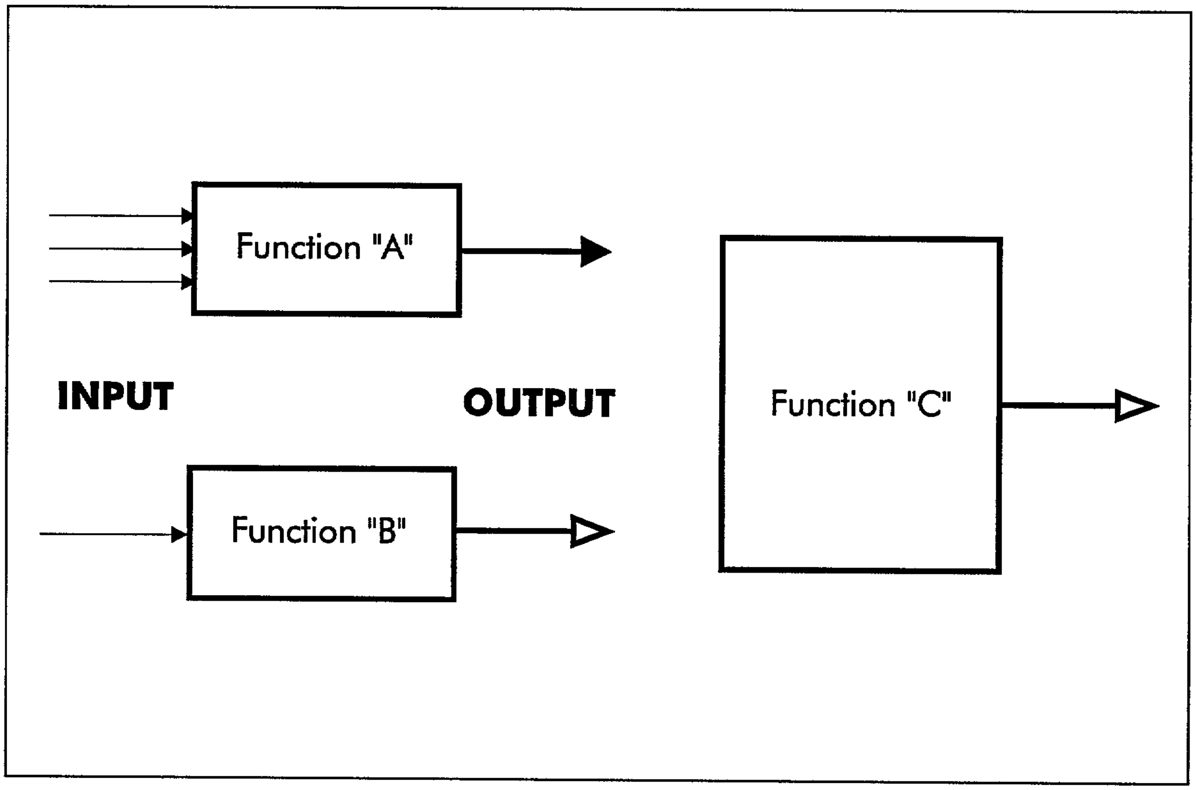

Figure 26. Example of a differential weight applied to a functional characteristic.

Measure of centrality. A variety of network analysis measures is available to estimate centrality of ATIS functional characteristics. Many of these measures make no distinction between inputs and outputs of a network. Because the network represented in table 24 does make this distinction (i.e., it is asymmetrical), a measure was chosen that accommodates the asymmetry of the matrix. As a consequence, this measure reflects the importance of functions based on information flows in and out of each function. Thus, each function has two measures of centrality, one as an input and one as an output. The input and output measures of centrality can be used to anticipate how people might need to interact with the system.

Functions with high levels of centrality, based on their output, represent functions that provide information to other functions. With these functions, the task analysis should focus on how the transfer of information from function to function may be facilitated by minimizing the amount of recoding and memory required of the driver. Conversely, functions that are highly central, based on the number of functions providing input, represent functions that tend to combine information from a variety of sources and then relay it to the driver. Passing information between functions will involve the driver in an entirely different set of tasks, compared to the tasks involved in acting on information provided by the system. Thus, a task analysis of these functions should focus on how the system conveys information to the driver, rather than on how information is passed between functions. In general, functions that are highly connected with other functions may merit special attention in the task analysis, because many aspects of the system may depend on them.

Freeman's measure of centrality (1979) estimates the centrality of the functional characteristics based on their output and input information flows. This estimate of centrality reflects the number of adjacent vertices to a given vertex, divided by the maximum possible vertices, and expressed as a percentage (Borgatti, Everett, & Freeman, 1992). For ease of understanding, a numerical example is provided.

As an example, five ATIS/CVO functions are considered. As table 24 shows, these functions are linked to other functions, but for simplicity, these links will be ignored for this example. The links between these five functions can be shown graphically, as in figure 27.

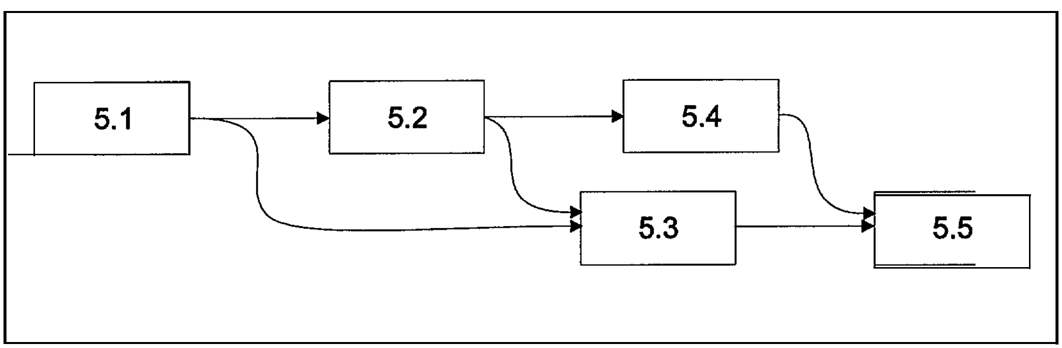

Figure 27. Graphical depiction of the information flows linking a subset of ATIS/CVO functions.

The links can also be shown as a matrix, as in table 26.

Table 26. Matrix of input/output (centrality/links).

	Function	OUTPUTS 5.1	5.2	5.3	5.4	5.5
I	5.1	0	1	1	0	0
N	5.2	0	0	1	1	0
P	5.3	0	0	0	0	1
U T	5.4	0	0	0	0	1
S	5.5	0	0	0	0	0

Using the data in this table, the input and output centrality of each function can be calculated. To determine the input centrality, the number of inputs to a function are added (adjacent vertices). This number is divided by the total possible inputs (total vertices). For function 5.1, the input centrality is the number of inputs divided by the total possible inputs (0/4 = 0 percent). This results because function 5.1 has no inputs and a possible total of four inputs. For function 5.2, the input centrality is l/4 = 25 percent, because table 27 shows one input to function 5.2 out of a possible four inputs.

Output centrality is calculated in the same manner. For example, function 5.1 has outputs to functions 5.2 and 5.3. Since the output centrality is the total number of outputs divided by the total possible inputs, the output centrality for function 5.1 is 2/4 = 50 percent. The input and output centrality for each function in this example is summarized below.

Table 27. Calculating input and output centrality.

Function	Input Centrality	Output Centrality
5.1	0	50
5.2	25	50
5.3	50	25
5.4	25	25
5.5	50	0

Table 28 summarizes this measure of centrality. Input centrality is proportional to the number of functions that a given function receives, while output centrality is proportional to the number of functions to which a given function provides information. In other words, a function that has a large number of outputs has a greater output centrality than a function that has fewer outputs. For example, table 28 shows that destination coordination (6.3) and route navigation (5.6) are very central in terms of the inputs they receive from other functional characteristics. Table 28 also shows road condition information (8.2) to be central based on the input it provides to other functional characteristics. These two facts are illustrated in figure 28. To ensure that the scenarios accurately represent the ATIS, several scenarios should include functional characteristics that are highly central; otherwise, scenarios may fail to capture a representative set of tasks associated with the functional characteristics critical to system success.

Table 28. Centrality measures for private driver functional characteristics.

FUNCTION		INPUT CENTRALITY	OUTPUT CENTRALITY
IRANS	5.1	16	44
	5.2	27	16
	5.3	27	38
	5.4	33	28
	5.5	17	0
	5.6	44	11
	5.7	0	17
IMSIS	6.1	17	17
	6.2	11	22
	6.3	44	6
	6.4	17	0
ISIS	7.1	28	11
	7.2	17	6
	7.3	0	0
IVSAWS	8.1	11	22
	8.2	17	50
	8.3	6	11
	8.4	17	22
	8.5	0	28
MEAN		18.42	18.42
STANDARD DEVIATION		12.88	14.20

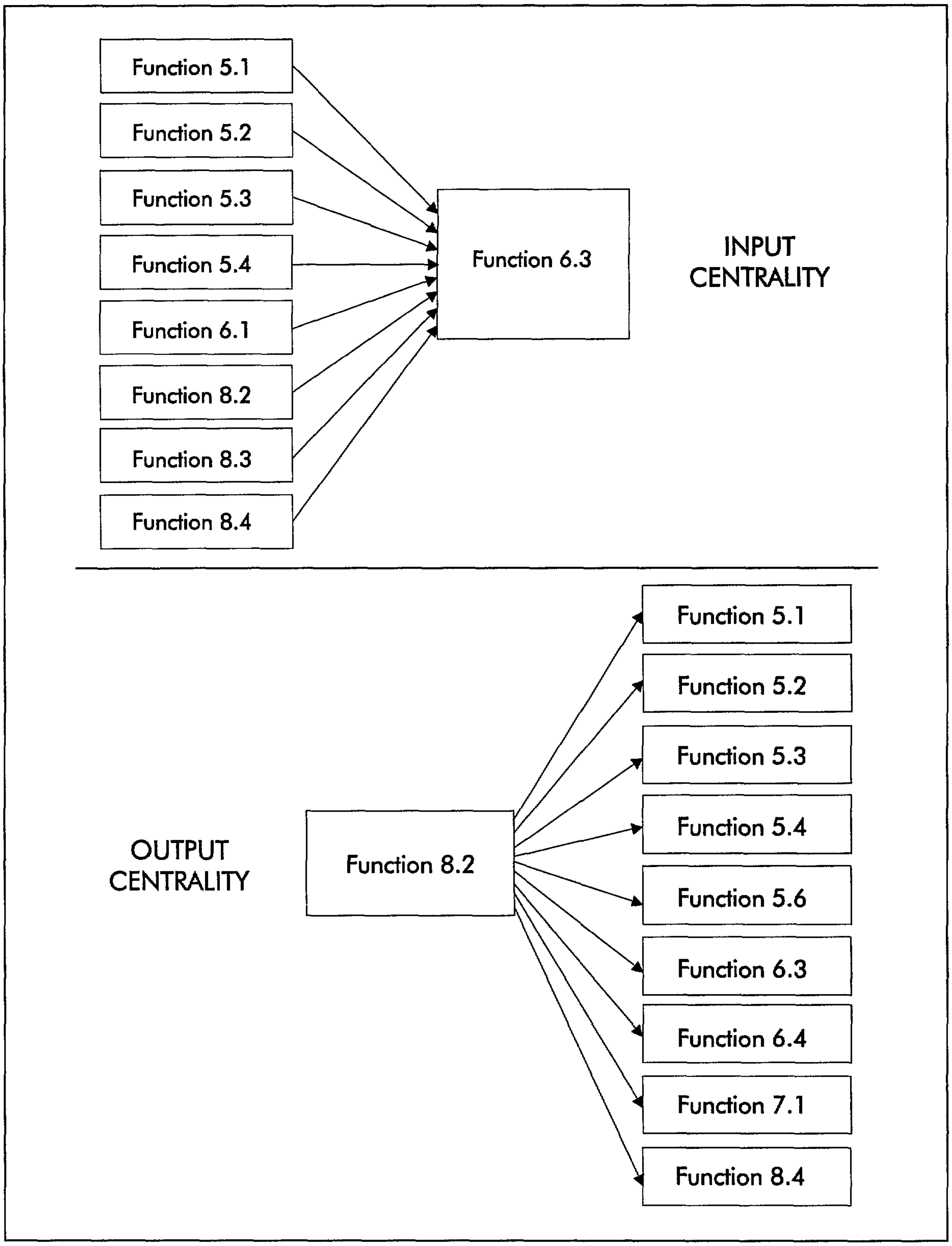

Figure 28. Examples of input and output centrality.

In conclusion, based on the network analyses for the private group, the centrality measures indicate that seven measures were found to be highly central. They are:

- 5.1 Trip planning.
- 5.2 Multi-mode travel coordination and planning.
- 5.3 Pre-drive route and destination selection.
- 5.4 Dynamic route selection.
- 5.6 Route navigation.
- 6.3 Destination coordination.
- 8.2 Road condition information.

<u>Cliques</u>

In addition to estimates of the centrality of each functional characteristic, an estimate of how information flows link functional characteristics into groups is an important element in identifying representative scenarios. If scenarios contain arbitrary sets of functions, they are unlikely to reveal representative information transfers between functional characteristics. Two network analyses were performed to explain how information flows link groups of functional characteristics. One analysis identified cliques and one identified clusters or "factions." Each uses a different criteria to group functional characteristics, but provides converging measures of groups of functional characteristics linked by information flows.

A clique is a formal description of the density of links between nodes of a network. The density of links is equal to the total number of links divided by the number of nodes present. For example, if the number of links between two groups of functions is equal, the group that has the smallest number of functions (nodes) would have the greatest density of links. A clique also represents a maximally complete subgraph, which is defined as a coherent grouping of nodes connected by links or information flows. In other words, a clique is defined as a set of nodes that are directly linked to each other. Each member of a clique must have at least as many connections to other functional characteristics as there are members in the clique. Specifically, in a clique of three nodes, each node must have links to each of the other nodes in the clique (three) plus any other links to other nodes in the network that are not part of the clique. Thus, a clique shows a group of functions that share information directly between each other. For the private application of ATIS, the network analysis (see table 29) identifies 20 cliques of three functions or more (a clique of two is trivial, simply a pair of linked nodes). These results suggest that the selection of scenarios should include those that consist of groups of functional characteristics from the 20 combinations.

<u>Clusters</u>

A cluster or faction (Borgatti, Everett, & Freeman, 1992) analysis represents another network analysis method that can identify groups of functional characteristics linked by their information flows. The cluster analysis extracts "factions" and does not impose the same strict, formal definition on the members of a group that a clique does. This analysis

Table 29. Cliques for private functions.

CLIQUE	FUNCTIONS				
1	5.1	5.2	5.3	5.6	6.2
2	5.1	5.2	5.3	5.6	8.2
3	5.1	5.3	5.6	6.1	
4	5.1	5.3	5.6	7.1	8.2
5	5.1	5.3	5.6	7.2	
6	5.1	5.2	5.3	5.7	
7	5.1	5.2	5.3	6.3	8.2
8	5.1	5.3	6.1	6.3	
9	5.3	5.5	7.1		
10	5.4	5.6	7.1	8.1	
11	5.4	5.6	7.1	8.2	
12	5.4	5.6	6.1		
13	5.2	5.4	5.6	8.2	
14	5.4	5.6	7.2		
15	5.4	5.5	7.1		
16	5.2	5.4	6.3	8.2	
17	5.4	6.1	6.3		
18	5.4	6.1	8.5		
19	6.3	6.4	8.2	8.4	
20	6.2	8.4	8.5		

optimizes a cost function that is based on the extent that a group of functional characteristics consists of linked clique-like structures (Borgatti, Everett, & Freeman, 1992). Thus, the cluster analysis identifies groups of functional characteristics in a manner vaguely analogous to factor analyses in traditional statistics. Table 30 summarizes the results of the analysis when five clusters were specified. Two of the five clusters were not considered meaningful as they contained functions that interacted only with themselves. The five clusters for the private operations consist of the functions listed in table 31.

Table 30. Clusters for private functions.

FUNCTION	5.1	5.2	5.3	5.4	8.2	5.6	7.1	7.2	5.7	6.2	8.1	8.5	8.4	8.3	6.1	6.4	6.3	7.3	5.5
5.1	1				1				1	1									
5.2	1	1			1	1			1	1									
5.3	1	1	1		1				1	1									
5.4		1		1	1	1					1	1			1				
8.2	1		1	1	1														
5.6	1		1		1	1	1	1		1	1				1				
7.1	1		1	1	1		1				1								
7.2	1		1	1				1											
5.7									1										
6.2										1		1	1						
8.1											1		1	1					
8.5												1							
8.4					1						1	1	1						
8.3												1		1					
6.1	1		1									1			1				
6.4					1								1			1	1		
6.3	1	1	1	1	1								1	1	1		1		
7.3																		1	
5.5			1	1			1												1

Table 31. Private vehicle cluster analysis.

CLUSTER 1: PLANNING AND NAVIGATION	
5.1 Trip planning	IRANS
5.2 Multi-mode travel coordination and planning	IRANS
5.3 Pre-drive route and destination selection	IRANS
5.4 Dynamic route selection	IRANS
5.6 Route navigation	IRANS
7.1 Guidance sign information	ISIS
8.2 Road condition information	IVSAWS
CLUSTER 2: MISCELLANEOUS FUNCTIONS	
This cluster is not meaningful. It is composed of two functions and each interacts only with itself.	
CLUSTER 3: AID AND EMERGENCY SERVICES	
6.2 Services/attractions directory	IMSIS
8.1 Immediate hazard notification	IVSAWS
8.3 Automatic aid request	IVSAWS
8.4 Manual aid request	IVSAWS
8.5 Vehicle condition monitoring	IVSAWS
CLUSTER 4: TRAVEL COORDINATION	
6.1 Broadcast services/attractions	IMSIS
6.3 Destination coordination	IMSIS
6.4 Message transfer	IMSIS
CLUSTER 5: MISCELLANEOUS FUNCTIONS	
This cluster is not meaningful. It is composed of two functions and each interacts only with itself.	

These clusters of functions can help guide the task analysis by identifying scenarios that consist of functions within a single cluster and scenarios that require functions from several clusters. A task analysis of a scenario that consists of functions from a single cluster can reveal the requirements of supporting a driver with what should be an integrated set of functions (from the perspective of the information flows that generated the clusters). One interesting result of the cluster analysis is that the resulting clusters do not correspond only to the ATIS subsystems (IRANS, IMSIS, ISIS, IVSAWS). Nevertheless, these distinctions do indeed capture an essential feature: IRANS-Cluster 1, IVSAWS-Cluster 3, and IMSIS-Cluster 4.

Functional Characteristics Included in the Commercial Vehicle Task Analysis

Frequency Count

A similar analysis using the matrix of information flows between functions (see table 32) was performed for the ATIS/CVO functional characteristics appropriate for commercial drivers. The results of the rank ordering of each function according to interactions with other functions are listed in table 33. Once more, the functions are ranked from those with the

Table 32. Information flows between functions for commercial vehicle operations.

		OUTPUTS																								
		IRANS								IMSIS				ISIS				IVSAWS						CVO				
		5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	6.1	6.2	6.3	6.4	7.1	7.2	7.3	7.4	8.1	8.2	8.3	8.4	8.5	8.6	9.1	9.2	9.3	9.4	TOTAL
INPUTS	IRANS	5.1	0	1	1	0	0	1	0	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0	1	1	1	1	12
		5.2	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	8
		5.3	0	0	0	0	1	1	0	1	1	0	1	0	1	1	0	0	0	1	0	0	0	0	1	1	1	1	12
		5.4	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	1	1	0	0	7
		5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5.6	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
		5.7	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	6
		5.8	0	0	1	1	0	1	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	1	1	1	1	11
	IMSIS	6.1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
		6.2	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
		6.3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
		6.4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3
	ISIS	7.1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
		7.2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7.4	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	6
	IVSAWS	8.1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	4
		8.2	1	1	1	1	0	1	0	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	1	0	0	12
		8.3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	5
		8.4	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	6
		8.5	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1	10
		8.6	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1	10
	CVO	9.1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
		9.2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	5
		9.3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4
		9.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	3
TOTAL			5	5	8	11	3	10	0	8	5	3	9	6	5	3	0	2	1	4	2	4	0	1	13	16	10	7	
			17	13	20	18	3	12	6	19	8	8	11	9	7	4	0	8	5	16	7	10	10	11	15	21	14	10	INTERACTION TOTAL
			5	9	2	4	25	10	22	3	18	18	11.5	16	20.5	24	26	18	23	6	20.5	14	14	11.5	7	1	8	14	RANK

Table 33. Rank ordering of the commercial functional characteristics.

RANK	FUNCTION		SYSTEM
1	9.2	Dispatch	CVO-specific
2	5.3	Pre-drive route and destination selection	IRANS
3	5.8	Route scheduling	CVO-specific
4	5.4	Dynamic route selection	IRANS
5	5.1	Trip planning	IRANS
6	8.2	Road condition information	IVSAWS
7	9.1	Fleet resource management	CVO-specific
8	9.3	Regulatory administration	CVO-specific
9	5.2	Multi-mode travel coordination	IRANS
10	5.6	Route navigation	IRANS
11.5	6.3 8.6	Destination coordination Cargo and vehicle monitoring	IMSIS IVSAWS
14	8.4 8.5 9.4	Manual aid request Vehicle condition monitoring Regulatory enforcement	IVSAWS IVSAWS CVO-specific
16	6.4	Message transfer	IMSIS
18	6.1 6.2 7.4	Broadcast services/attractions Services/attractions directory Road restriction information	IMSIS IMSIS CVO-specific
20.5	7.1 8.3	Guidance information Automatic aid request	ISIS IVSAWS
22	5.7	Automated toll collection	IRANS
23	8.1	Immediate hazard warning	IVSAWS
24	7.2	Notification information	ISIS
25	5.5	Route guidance	IRANS
26	7.3	Regulatory information	ISIS

most interactions to those with the least. This table indicates that dispatch is the most frequent interacting function, closely followed by the pre-drive route and destination selection, which also happened to be the most frequent interacting function for the private vehicle operations.

Network Analyses

An analysis was performed of the network formed by the ATIS and the CVO-specific functional characteristics and the information flows that connect them. This analysis parallels that done for the private drivers.

Measure of centrality. Freeman's measures of centrality for functional characteristics of commercial drivers show differences in comparison to the analysis of the private drivers. For the commercial drivers, dispatch (9.2) appeared to be most central in terms of information received from other functional characteristics. Three functional characteristics all had the same measure of centrality, based on the information they provided to other functional characteristics; i.e., trip planning (5.1), pre-driver route and destination selection (5.3), and road condition information (8.2). Table 34 summarizes these results.

Table 34, Centrality measures for commercial driver functional characteristics.

FUNCTION		INPUT CENTRALITY	OUTPUT CENTRALITY
TRANS	5.1	20	48
	5.2	20	32
	5.3	32	**48**
	5.4	44	28
	5.5	12	0
	5.6	40	8
	5.7	0	24
	5.8	32	44
IMSIS	6.1	20	12
	6.2	12	20
	6.3	36	8
	6.4	24	12
ISIS	7.1	20	8
	7.2	12	4
	7.3	0	0
	7.4	4	24
IVSAWS	8.1	8	16
	8.2	16	**48**
	8.3	8	20
	8.4	16	24
	8.5	0	40
	8.6	0	40
CVO	9.1	52	8
	9.2	68	20
	9.3	40	16
	9.4	28	12
MEAN		21.69	21.69
STANDARD DEVIATION		17.12	14.89

Cliques

Using the CVO functions, there was a possibility of 57 cliques containing 3 or more functions. Considering that a clique indicates that each function is immediately linked to the others in the clique, this measure becomes a very constrained way for functions to interact. Table 35 indicates the first 29 cliques in the analysis. Considering that quite a large number of cliques exist for the CVO, it is easy to select scenarios that would reflect some of these groups of functional characteristics.

Table 35. Cliques for commercial functions.

CLIQUE	FUNCTIONS					
1	5.1	5.2	5.3	6.3	8.2	9.2
2	5.1	5.2	5.3	8.2	8.6	9.2
3	5.1	5.2	5.3	5.7	9.1	9.3
4	5.1	5.2	5.3	9.1	9.2	9.3
5	5.1	5.2	5.3	5.6	6.1	
6	5.1	5.2	5.3	5.6	8.2	
7	5.1	5.3	5.6	7.1	8.2	
8	5.1	5.3	7.4	9.1	9.2	
9	5.1	5.3	7.4	9.2	9.4	
10	5.2	5.3	5.8	6.3	8.2	9.1
11	5.2	5.3	5.8	8.2	9.1	9.2
12	5.2	5.3	5.7	5.8	9.2	9.3
13	5.2	5.3	5.8	9.2	9.3	9.4
14	5.2	5.3	5.6	5.8	6.2	
15	5.2	5.3	5.6	5.8	8.1	
16	5.2	5.4	5.8	6.3	8.2	9.1
17	5.2	5.4	5.8	8.2	9.1	9.2
18	5.2	5.4	5.8	9.2	9.3	
19	5.4	5.8	8.5	9.1	9.2	
20	5.4	5.8	8.5	9.2	9.3	
21	5.4	5.8	8.6	9.1	9.2	
22	5.4	5.8	8.6	9.2	9.3	
23	5.2	5.4	5.6	5.8	8.2	
24	5.8	6.4	8.2	9.1	9.2	
25	5.8	6.3	6.4	8.2	9.2	
26	6.4	8.2	8.4	9.1	9.2	
27	6.3	6.4	8.2	8.4	9.2	
28	5.8	8.5	9.2	9.3	9.4	
29	5.8	8.6	9.2	9.3	9.4	

Clusters

The cluster analysis grouped the functions into five distinct clusters (see table 36). The five clusters for the commercial vehicle analysis are listed in table 37. The cluster analysis generated interesting results in the sense that except for one, each cluster organized functional characteristics into meaningful goals or sets of activities. These clusters did not correspond to the formal groupings of functional characteristics (IRANS, IMSIS, ISIS, IVSAWS, and CVO-specific) as closely as they did for the private-driver analysis. As a consequence, these findings suggest that it is important to attend closely to the CVO-specific functions as they tend to interact with the other functions in a way that alters the groupings found in the private applications.

Table 36. Clusters for commercial functions.

FUNCTION	9.1	5.8	5.3	8.2	6.4	6.3	9.2	7.2	7.1	5.4	8.1	5.6	5.7	5.2	9.3	5.1	9.4	7.3	5.5	7.4	8.3	6.1	6.2	8.5	8.6	8.4
9.1	1	1	1	1	1					1				1		1				1	1			1	1	1
5.8		1	1	1	1								1	1									1	1	1	
5.3		1	1	1			1						1	1		1				1			1			
8.2		1	1	1						1						1										
6.4	1	1		1	1	1	1																			1
6.3		1	1	1		1				1				1		1					1	1				1
9.2	1	1	1	1	1	1	1			1			1	1	1	1	1			1	1			1	1	1
7.2			1					1		1						1										
7.1			1	1					1	1	1					1										
5.4		1		1			1			1	1	1		1	1					1		1		1	1	
8.1											1										1					1
5.6		1	1	1				1	1		1	1				1				1		1	1			
5.7													1													
5.2				1								1	1	1		1							1			
9.3		1	1				1						1	1	1	1	1				1			1	1	
5.1				1									1		1	1				1			1			
9.4		1	1											1	1	1	1							1	1	
7.3																		1								
5.5			1						1	1									1							
7.4																	1			1						
8.3																					1			1	1	
6.1		1	1													1						1		1	1	
6.2																							1	1	1	1
8.5																								1		
8.6																									1	
8.4				1							1													1	1	1

Table 37. Commercial vehicle cluster analysis.

CLUSTER 1: RESOURCE MANAGEMENT AND PLANNING	
5.3 Pre-drive route and destination selection	IRANS
5.8 Route scheduling	IRANS
6.3 Destination coordination	IMSIS
6.4 Message transfer	IMSIS
8.2 Road condition information	IVSAWS
9.1 Fleet resource management	CVO-specific
9.2 Dispatch	CVO-specific
CLUSTER 2: NAVIGATION AND ROUTE GUIDANCE	
5.4 Dynamic route selection	IRANS
5.6 Route navigation	IRANS
7.1 Guidance sign information	ISIS
7.2 Notification information	ISIS
8.1 Immediate hazard notification	IVSAWS
CLUSTER 3: REGULATORY AND ADMINISTRATIVE COORDINATION	
5.1 Trip planning	IRANS
5.2 Multi-mode travel coordination	IRANS
5.7 Automatic toll collection	IRANS
9.3 Regulatory administration	CVO-specific
9.4 Reaulatorv enforcement	CVO-specific
CLUSTER 4: MISCELLANEOUS FUNCTIONS	
This cluster was not meaningful. It was composed of four functions and each function was interacting only with itself; there were no interactions with any of the other functions.	
CLUSTRR 5: SERVICES REQUEST	
6.1 Broadcast services/attractions	IMSIS
6.2 Services/attractions directory	IMSIS
8.4 Manual aid request	IVSAWS
8.5 Vehicle condition monitoring	IVSAWS
8.6 Cargo condition monitoring	IVSAWS

SCENARIO SELECTION

Scenario Conceptualization

One of the main goals of the task analysis is that it be a systematic, top-down analysis of the tasks performed by users of ATIS/CVO systems in order to meet the required functions of each system. The task analysis should describe the set of tasks that a driver would have to perform in a realistic driving environment. These tasks include both driving-related tasks and ATIS/CVO-related tasks. To study the interactions between these two sets of tasks, it is necessary to have a fairly realistic setting. However, because these systems do not fully exist, it was useful to create fictional scenarios that would provide the context of a realistic environmental setting in order to explore how these two sets of tasks could interact.

Task B generated several scenarios, both for private and commercial operations. The purpose of these scenarios was to aid in the identification of ATIS features and functions, as well as to support the task analysis effort. The scenarios in Task B were not based on comprehensive analyses of ATIS features and functions, nor on a comprehensive analysis of the task of driving with the aid of an ATIS. In fact, they were created to represent a broad sample of the driving scenarios identified by the transportation community as part of the Task B effort. In general, they summarize the issues, capabilities, functions, and features specific to each one of the ATIS/CVO systems as identified during the course of Task B interviews.

Unfortunately, the conceptualization of these scenarios occurred before the completion of Task C, the purpose of which was to identify functional characteristics for each of the ATIS/CVO systems. In addition to identifying functional characteristics, Task C contributed to each of these scenarios by illustrating how each scenario draws upon a set of functional characteristics. Table 38 shows the functional characteristics used in the private vehicle scenarios, while table 39 shows the same breakdown for the commercial vehicle scenarios.

These two tables show two important facts. First, the scenarios developed in Task B do not span the entire range of functional characteristics. Some functional characteristics are not illustrated at all. For example, table 38 for private vehicle scenarios shows that as many as eight functional characteristics (5.2, 5.4, 5.7, 6.1, 6.3, 6.4, 7.1, and 8.3) were not considered in the conceptualization of these scenarios. Similarly, table 39 for the commercial vehicle scenarios shows that as many as nine functional characteristics (5.1, 6.1, 6.3, 7.1, 7.2, 7.3, 8.5, 8.6, and 9.4) failed to appear in any of the scenarios. Second, almost all scenarios showed an integration of more than one functional characteristic or ATIS subsystem into one situational context. As pointed out in Task C, this illustrates the importance of closely examining the interactions between functions to identify the coupling of various systems. By knowing how the functional characteristics interact within a subsystem or across systems, it will be possible to provide meaningful guidelines for the design of integrated ATIS/CVO systems rather than create a disconnected collection of independent functions and subsystems.

Considering that several functional characteristics failed to appear in the scenarios of Task B, it may be useful to enhance the scenarios in the context of the full list of functional characteristics developed in Task C. As a consequence, the initial set of scenarios was expanded, and the functional characteristic breakdown for each one of the new private vehicle scenarios is summarized in table 40, while the one for the commercial vehicle scenarios is reviewed in table 4 1.

Table 38. Functional characteristics used in private vehicle scenarios as originally designed in Task B.

FUNCTIONS	SCENARIOS												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
IRANS													
5.1 Trip planning		1		1	1								3
5.2 Multi-mode travel coordination and planning													0
5.3 Pre-drive route and destination selection	1		1		1	1		1					5
5.4 Dynamic route selection						1							1
5.5 Route guidance	1	1	1						1				4
5.6 Route navigation	1	1		1									3
5.7 Automated toll collection													0
IMSIS													
6.1 Broadcast services/attractions information													0
6.2 Services/attractions directory				1	1	1							3
6.3 Destination coordination						1							1
6.4 Message transfer													0
ISIS													
7.1 Roadway guidance sign								1					1
7.2 Roadway notification sign information									1				1
7.3 Roadway regulatory sign information							1	1	1				3
IVSAWS													
8.1 Immediate hazard warning										1	1		2
8.2 Road condition information											1	1	2
8.3 Automatic aid request													0
8.4 Manual aid request												1	1
8.5 Vehicle condition monitoring													0
Total	3	3	2	3	3	4	1	3	3	1	2	2	30

Table 39. Functional characteristics used in commercial vehicle scenarios as originally designed in Task B.

FUNCTIONS	SCENARIOS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
IRANS															
5.1 Trip planning															0
5.2 Multi-mode travel coordination and planning													1		1
5.3 Pre-drive route and destination selection		1	1												2
5.4 Dynamic route selection				1	1	1	1								4
5.5 Route guidance	1	1	1			1									4
5.6 Route navigation	1		1												2
5.7 Automated toll collection											1				1
5.8 Route scheduling												1	1	1	3
IMSIS															
6.1 Broadcast services/ attractions information															0
6.2 Services/attractions directory				1											1
6.3 Destination coordination															0
6.4 Message transfer	1											1	1	1	4
ISIS															
7.1 Roadway guidance sign															0
7.2 Roadway notification sign information															0
7.3 Roadway regulatory sign information															0
7.4 Road restriction information			1		1	1									3
IVSAWS															
8.1 Immediate hazard warning								1							1
8.2 Road condition information							1			1					2
8.3 Automatic aid request										1					1
8.4 Manual aid request									1						1

Table 39. Functional characteristics used in commercial vehicle scenarios as originally designed in Task B (continued).

FUNCTIONS	SCENARIOS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
IVSAWS (cont'd.)															
8.5 Vehiclecondition monitoring															0
8.6 Cargo condition monitoring															0
CVO															
9.1 Fleetresource management												1	1	1	3
9.2 Dispatch												1	1	1	3
9.3 Regulatory administration											1				1
9.4 Regulatory enforcement															0
Total	3	2	4	2	2	3	2	1	1	2	2	4	5	4	37

Table 40. Functional characteristics used in the expanded private vehicle scenarios.

FUNCTIONS	SCENARIOS																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	22	Total
IRANS																		
5.1 Trip planning		1		1	1													3
5.2 Multi-mode travel coordination and planning														1				1
5.3 Pre-drive route and destination selection	1	1	1		1	1		1						1	1	1		9
5.4 Dynamic route selection						1							1	1		1		4
5.5 Route guidance	1	1	1						1									4
5.6 Route navigation	1	1		1														3
5.7 Automated toll collection														1				1
IMSIS																		
6.1 Broadcast services/attractions information															1		1	2
6.2 Services/attractions directory				1	1	1												3
6.3 Destination coordination						1									1		1	3
6.4 Message transfer																1		1
ISIS																		
7.1 Roadway guidance sign								1										1
7.2 Roadway notification sign information									1									1
7.3 Roadway regulatory sign information							1	1	1								1	4
IVSAWS																		
8.1 Immediate hazard warning										1	1		1				1	4
8.2 Road condition information											1	1		1				3
8.3 Automatic aid request																	1	1
8.4 Manual aid request												1			1			2
8.5 Vehicle condition monitoring															1		1	2
Total	3	4	2	3	3	4	1	3	3	1	2	2	2	5	6	4	4	52

Table 41. Functional characteristics used in the expanded commercial vehicle scenarios.

FUNCTIONS	SCENARIOS															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
IRANS																
5.1 Trip planning																0
5.2 Multi-mode travel coordination and planning													1			1
5.3 Pre-drive route and destination selection		1	1									1				3
5.4 Dynamic route selection				1	1	1	1					1				5
5.5 Route guidance	1	1	1			1										4
5.6 Route navigation	1		1													2
5.7 Automated toll collection											1					1
5.8 Route scheduling													1	1		2
IMSIS																
6.1 Broadcast services/attractions information																0
6.2 Services/attractions directory				1											1	2
6.3 Destination coordination																0
6.4 Message transfer	1												1	1		3
ISIS																
7.1 Roadway guidance sign				1												1
7.2 Roadway notification sign information				1												1
7.3 Roadway regulatory sign information				1												1
7.4 Road restriction information			1	1	1	1										4
IVSAWS																
8.1 Immediate hazard warning				1				1								2
8.2 Road condition information							1			1		1				3
8.3 Automatic aid request										1						1
8.4 Manual aid request									1						1	2

Table 41. Functional characteristics used in the expanded commercial vehicle scenarios (continued).

FUNCTIONS	SCENARIOS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
IVSAWS (cont'd.)																
8.5 Vehicle condition monitoring																0
8.6 Cargo condition monitoring															1	1
CVO																
9.1 Fleet resource management													1	1		2
9.2 Dispatch												1	1	1		3
9.3 Regulatory administration											1					1
9.4 Regulatory enforcement											1					1
Total	3	2	4	7	2	3	2	1	1	2	3	4	5	4	3	46

Scenarios Selected for Analysis

Scenarios involving both private vehicle operations and commercial vehicle operations were selected to optimize the efficiency of the analysis. Scenarios were selected based on their representativeness in terms of the analysis that was done on the relative importance of functions as determined by information interactions and to represent several specific characteristics of the dynamic driving task that are likely to be of particular importance to an understanding of the way that drivers will interact with ATIS/CVO.

Private Vehicle Scenarios

Private Driving Scenarios Based on Frequency Count and Centrality Measure

The frequency count analysis and the centrality measure analysis showed that pre-drive route and destination selection was the functional characteristic that had the greatest number of interactions with other functions and that was also considered the most central. Scenario P6 (see table 42) was chosen because it was one of the original scenarios developed in Task B and because it included pre-drive route and destination selection and other functional characteristics that were considered relatively central as well (e.g., destination coordination).

Table 42. Description of Scenario P6.

PURPOSE	To show the centrality of pre-drive route and destination selection.
SUMMARY	A driver is on an extended driving vacation. He has stopped approximately 50 miles (80.5 km) from his destination to review motel options for the evening at his destination point. He accesses the IMSIS directory for the town he will be staying in, reviews several alternative motels, and selects three that are located in one specific area and look interesting. Before proceeding toward his destination, he makes a reservation using ATIS.

SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS IMSIS	5.3 Pre-drive route and destination selection 5.4 Dynamic route selection 6.2 Services/attractions directory 6.3 Destination coordination

Private Driving Scenarios Based on Functional Clusters

The cluster analysis organized the functional characteristics into a pre-selected number of groups, or clusters. Out of the five specified clusters, three formed meaningful groupings. Each cluster represents a grouping of functions that are related to more than one ATIS subsystem. Considering that each cluster grouped functional characteristics that were linked together according to the network analysis, they formed fairly homogeneous groups. The first cluster includes functional characteristics related to planning and navigation, the second cluster is associated with aid and emergency services, the third cluster has to do with travel coordination.

For each one of these clusters, a scenario was chosen that illustrates one particular situation in which these functional characteristics are interacting together. However, it is important to note that these scenarios illustrate one of several possible alternatives for combining these various functions into one situational context.

Alternatively, it is interesting to consider scenarios that illustrate interactions between different clusters in addition to interactions between functions within the same cluster. In this regard, Scenario P6 (above) is one such example that shows an interaction between the three different clusters. The interest in these cluster interactions stems from the fact that these particular scenarios not only show the requirements of supporting a task that requires the interactions with different subsystems, but also tasks that require a diverse set of functions.

Cluster 1. This cluster groups functional characteristics that span across three different ATIS subsystems, although the emphasis is mainly on IRANS. This cluster is also the largest of the three, grouping on the whole with seven different functional characteristics. Table 43 is a description of Scenario P14.

Table 43. Description of Scenario P14.

PURPOSE	**To illustrate a grouping of functional characteristics from Cluster 1 (5.1, 5.2, 5.3, 5.4, 5.6, 7.1, and 8.2).**
SUMMARY	A driver commutes between her home and the office. The commute requires coordination between three different modes of transportation. She drives the first 10 miles (16.1 km) and then has to decide between taking the ferry across the Bay or driving around the Bay Area. Once she is on the other side of the Bay, she has to drive for another 5 miles (8.0 km) to a park-and-ride lot where she takes a bus to the office. However, she can choose to reject the bus option and drive an additional 10 miles (16.1 km) if the traffic is light. It is a cold winter day and the roads are icy. She needs to get to work in the shortest amount of time possible. She uses her ATIS to plan her trip to the office and to coordinate the travel between the different modes of transportation. After taking the ferry and paying the toll, and while traveling to the bus stop, her ATIS informs her of icy conditions on the road and of bus delays. She selects an alternate route and continues her drive to work.

SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS	5.2 Multi-mode coordination and planning 5.3 Pre-drive route and destination selection 5.4 Dynamic route selection 5.7 Automatic toll collection 8.2 Road condition information

Cluster 2. This cluster of functional characteristics focuses mainly on aid requests as well as on emergency services needs. Most of the functions included in this cluster are related to IVSAWS, except for the services/attractions directory that is provided by IMSIS. As shown in table 44, this particular scenario uses three out of the five possible functional characteristics.

Table 44. Description of Scenario P22.

PURPOSE	**To illustrate a grouping of the functional characteristics found in Cluster 2** (6.2, 8.1, 8.3 8.4, and 8,5),
SUMMARY	A driver travels on a secondary road where there are numerous speed changes due to the presence of several small towns. As he is driving, IVSAWS detects a malfunction of the car's brakes. The driver takes notice of the message and continues to his destination. Later on, he receives another message of road construction ahead. The driver applies the brakes, but it is too late; the car collides with a construction vehicle merging from the side of the road. The ATIS activates the aid request to provide assistance to the driver, who is unconscious.

SYSTEM	FUNCTIONAL CHARACTERISTICS
ISIS IVSAWS	7.3 Roadway regulatory sign information 8.1 Immediate hazard warning 8.3 Automatic aid request 8.5 Vehicle condition monitoring

Cluster 3. This cluster facilitates the travel coordination required by a driver going to either a service facility or a tourist attraction. In addition, this cluster enables the coordination between parties if one of them needs to be informed of delays or other unusual circumstances. Scenario P16 refledts multiple interactions with the system and, at the same time, combines the three functional characteristics that make up Cluster 3 (see table 45).

Table 45. Description of Scenario P16.

PURPOSE	**To illustrate a grouping of functional characteristics from Cluster 3 (6.1, 6.3, and 6.4).**
SUMMARY	A driver uses ATIS to travel from her hotel to a restaurant on the outskirts of town. While traveling, she receives notification that the engine's oil temperature is increasing. Fearing engine damage, she pulls off the road. The driver then identifies a service station close by. She requests the assistance of a tow truck and cancels her dinner reservation. She also communicates with her friend to inform her of the misadventure with the vehicle and to ask to be picked up at the service station.

SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS IVSAWS IMSIS	5.3 Pre-drive route and destination selection 6.2 Broadcast services/attraction 6.3 Destination coordination 6.4 Message transfer 8.3 Manual aid request 8.5 Vehicle condition monitoring

Private Driving Scenarios Based on the Nature of Task Interactions

As illustrated in the scenarios above, functional characteristics, either ATIS-related and/or driving-related, have a tendency to operate in groups. In some instances, several functions originate from only one specific ATIS subsystem. In other circumstances, one or several functional characteristics from two subsystems or more are used in the same situational context. The nature of the interactions between these various functional characteristics varies and has some important implications for the task analysis breakdown. In fact, the interactions between various functional characteristics can be categorized into three different types: (1) sequential, (2) branching, and (3) recursive. Each of these types of interactions will be described in one of the following subsections. Although it is possible to be in an environmental context that could combine the three different types of interactions, for ease of clarity, the present task analysis will focus on scenarios that illustrate only one type of functional interaction at a time.

Private driving scenario based on sequential functions. This type of interaction is the simplest of all three types, as each functional characteristic occurs in sequence with the other. In other words, the driver has to complete a set of tasks associated with a particular function before he or she can proceed with the other functions.

Scenario Pl was chosen to illustrate the nature of sequential functions for four reasons: (1) it is a scenario that was designed as part of Task B and did not need to be modified; (2) it focuses on the pre-drive route and destination selection, which is the most central measure; (3) it is relatively simple, using only three functional characteristics that belong to the same subsystem, IRANS; and (4) it includes two functional characteristics that were not included in any of the scenarios chosen so far (see table 46).

Table 46. Description of Scenario Pl.

PURPOSE	**To illustrate the sequencing type of interactions among various functional characteristics.**
SUMMARY	A driver vacationing with his family in an urban setting arrives at the airport in mid-afternoon and rents a car with an IRANS device installed. The family's plan is to go directly to their hotel located in the city 10 miles (16.1 km) from the airport. The weather is good, but there is a substantial level of congestion on the major highways between the airport and the hotel due to normal commuting traffic. After receiving a brief orientation on using IRANS at the rental office, the driver identifies his destination on the IRANS and requests the fastest route. The IRANS recommends a route that the driver accepts and he begins his trip to the hotel.
SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS	5.3 Pre-drive route and destination selection 5.5 Route guidance 5.6 Route navigation

Private driving scenario based on branching functions. When a driver has completed a sequence of tasks from one particular functional characteristic and is at a way-point having to choose between two different functions, each with its particular set of tasks, the driver is, in fact, choosing between two different branches of the task descriptions (see table 47). When the driver chooses to accomplish function "A," for example, he or she will not accomplish function "B." By choosing "A" instead of "B," the driver defines the path taken. In some instances, the sequence of functions is the same whether the driver chooses "A" or "B"; in other circumstances, the path will remain different throughout the entire remainder of the sequence.

Table 47. Description of Scenario P20.

PURPOSE To illustrate the branching type of interactions among various functional characteristics	
SUMMARY It is Friday afternoon and a driver is following her IRANS' guidance in traveling back to her hotel from an appointment with a client. As she drives, she receives the broadcast signal of a nearby winery. She debates between continuing to her hotel or visiting the winery. She uses the ATIS to verify if the winery is open and makes a reservation for the next guided tour. Moments later, she requests a dynamic route change to proceed towards the winery.	
SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS IMSIS	5.3 Pre-drive route and destination selection 5.4 Dynamic route change 6.2 Broadcast services/attractions 6.3 Destination coordination

Private driving scenario based on recursive functions. In this instance, the functions are not following each other in a sequence, but rather require that the driver repeat a step that previously had been partially or entirely completed. In other words, this type of interaction implies that a driver can accomplish a given set of tasks associated with a given function, continue to another function, and come back to that first function later on. The rationale for such a set of interactions is that the outcome of one particular functional characteristic may require additional information or transformation before proceeding to the next one.

Scenario P2 (shown in table 48) was chosen for three different reasons. First, it illustrates a type of interacting functions that could be repeated more than once, if needed. Second, this scenario was also favored because it originated from Task B's initial set of scenarios. Finally, Scenario P2 adds one more function (trip planning) to the overall set of functional characteristics analyzed so far.

Private Driving Scenario Based on High Workload Demands

One of the main concerns of the implementation of these ATIS is that they interact with the existing driving tasks. In fact, it becomes essential to investigate to what degree ATIS demands will impair or facilitate the driving task. In some instances in which the driver is required to operate under high demands, such as traveling in an unknown city during bad weather, the ATIS might be more negative than beneficial. The purpose of this scenario is to provide an example of how various functions could interact during an already demanding driving task (see table 49).

Table 48. Description of Scenario P2.

PURPOSE	To illustrate the interactions among various functional characteristics.
SUMMARY	A real estate salesperson is meeting a couple at their residence. She plans on showing them several houses in a suburban area of a major city. She has selected houses in several different neighborhoods spaced around one side of the city. The neighborhoods can be reached by either highways or arterials. It is evening, there is a heavy rain, and there is an accident on one of the highways that could be taken. Two neighborhoods that would be reasonable starting points for the evening's viewing are approximately equidistant from the clients' current residence. The salesperson would like to go to the neighborhood that can be most easily reached first. Prior to picking up her clients, she enters the addresses of all of the houses in the IRANS. During the drive to her clients' house, she monitors the traffic congestion in the planned area of travel. When she arrives at the clients' residence, she requests a comparison of travel times and selects the route that is predicted to take the least time. She then reviews current traffic congestion. Finally, she picks up her clients and drives them to the first house.

SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS	5.1 Trip planning 5.5 Route guidance 5.6 Route navigation

Table 49. Description of Scenario P8.

PURPOSE	To illustrate that the requirements generated by ATIS may impose high workload demands on the driver.
SUMMARY	A business traveler is driving in the suburbs of a major city he is not familiar with during a heavy snowstorm at dinner time. He has selected a 20-mile (32.2-km) drive, recommended by the ATIS, from his hotel to his first destination that is predominantly on arterial roads. In fact, the drive is not a straight line, but rather a series of turns to various arterial roads (no highways). The heavy snow is making visibility poor and the roads icy. He requests that the ATIS provide him with street signs and interchange graphics as well as stop signs and lane-use control information. Halfway to his destination, he is informed of an accident and of his need to select an alternate route. As he is examining two alternatives, the ATIS warns him of an approaching emergency vehicle. He slows down, pulls over, and enters his route choice. After the emergency vehicle passes, he continues traveling to his destination.

SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS ISIS IVSAWS	5.3 Pre-drive route and destination selection 7.1 Roadway guidance sign information 7.3 Roadway regulatory sign information 8.1 Immediate hazard warning 8.2 Road condition information

the driver chooses to accomplish function "A," for example, he or she will not accomplish function "B." By choosing "A" instead of "B," the driver defines the path taken. In some instances, the sequence of functions is the same whether the driver chooses "A" or "B"; in other circumstances, the path will remain different throughout the entire remainder of the sequence.

Commercial Vehicle Scenarios

Commercial Driving Scenarios Based on Frequency Count and Centrality Measure

The frequency count analysis and the centrality measure analysis showed that dynamic route selection was the functional characteristic that had the greatest number of interactions with other functions, while dispatch was considered the most central. In addition to these two measures, route scheduling and road condition information were also considered quite central as well.

Scenario C12 (shown in table 50) was chosen because it included three of the most central and most frequently interacting functional characteristics (5.3, 8.2, and 9.2). In addition, this scenario illustrates the interactions between two different subsystems, while accentuating CVO-specific characteristics.

Table 50. Description of Scenario C12.

PURPOSE	To illustrate the functional characteristic that had the greatest frequency count, dynamic route selection, and the one that was considered the most central, dispatch.
SUMMARY	It is Friday evening, during rush hour traffic, just before a holiday. The commute is slow because it is snowing and several accidents obstruct the traffic circulation. A central dispatcher for medical aid vehicles in a large metropolitan area is working her normal evening shift. She receives two concurrent emergency calls for aid required at a freeway accident and a private residence. The dispatcher enters the locations of the emergencies into her routing system and the system determines the appropriate medical aid vehicle stations to call and the appropriate routes to take, based on the fastest predicted travel time under current traffic and road conditions. Upon reception of that information, she informs the appropriate drivers of the new destination and route to take. The drivers enter the routing into their ATIS and activate IVSAWS to provide them with updated road condition information. As one of the drivers is driving to the residential call, he is informed of severe icing along the route. He requests a route change from his ATIS and continues to the residence.

SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS IVSAWS CVO-SPECIFIC	5.3 Pre-drive route and destination selection 5.4 Dynamic route selection 8.2 Road condition information 9.2 Dispatch

Commercial Driving Scenarios Based on Functional Clusters

As indicated in the private scenarios section, this cluster analysis organizes the functional characteristics into five pre-specified groups (clusters). In the case of the commercial scenarios, out of the five specified clusters, four of them had a meaningful relationship. The first cluster has been labeled Resource Management and Planning as it groups functions that related mostly to fleet resource management and dispatch. The second cluster is called Navigation and Route Guidance and includes both IRANS and ISIS functions, except for the immediate hazard warning from IVSAWS. The third cluster is concerned with Regulatory and Administration Coordination as three of its functions are related to the regulatory or administrative agencies. The fourth cluster was not included in this analysis, as it was indicated in the function selection section of this document. Finally, the fifth cluster is named Services Request because it includes the functional characteristics related to services and attractions as well as the manual aid request function. For each one of these clusters, a scenario has been chosen that illustrates one particular situation. As mentioned previously, these scenarios are only one example of the many mapping between functional characteristics.

Cluster 1. This cluster has functional characteristics that span across three different ATIS subsystems, in addition to some of these functions being specific to CVOs. This cluster of functions is the largest of the four, grouping on the overall seven functional characteristics. A description of Scenario Cl3 is shown in table 43.

Table 51. Description of Scenario C13.

PURPOSE	**To illustrate a grouping of functional characteristics from Cluster 1 (5.3, 5.8, 6.3, 6.4, 8.2, 9.1, and 9.2).**
SUMMARY	A central dispatcher coordinates the progress of 20 separate vans that provide door-to-door airport transportation in one suburban section of a major metropolitan area. Service is provided on demand so that calls are responded to within a specified period of time. If the caller is not picked up within the specified time, the cost of the ride is reduced by 50 percent and a report must be filed by the driver and dispatcher. A dispatcher is also rewarded for making the maximum use of available vans, as determined by the fleet routing system. The dispatcher prepares the first pick-up schedule of the day and transmits this information to the drivers.
SYSTEM	FUNCTIONAL CHARACTERISTICS
IRANS IMSIS IVSAWS	5.8 Route scheduling 6.4 Message transfer 9.1 Fleet resource management 9.2 Dispatch

Cluster 2. This cluster focuses mainly on navigation and route guidance. The functions, once more, originate from three different systems (IRANS, ISIS, and IVSAWS). Scenario C4 was chosen as it includes four out of the five functional characteristics that make up Cluster 2 (see table 52). It is also interesting to note that the functional characteristics that make up this cluster (5.4, 5.6, 7.1, 7.2, and 8.1) are not specifically related to CVO operations.

Table 52. Description of Scenario C4.

PURPOSE	**To illustrate a grouping of the functional characteristics found in Cluster 2 (5.4, 5.6, 7.1, 7.2, and 8.1).**
SUMMARY	A young interstate truck operator is traveling at night on a narrow, two-way road. As he is traveling, his IVSAWS provides advance warning of the road closure due to a new construction zone ahead. Because the road closure occurs just prior to a planned refueling stop, the driver uses his ATIS to determine the nearest service station. Having selected one, he requests a dynamic route change to proceed to the station and the help of ISIS to provide speed-limit transitions, street signs, and merge signs.
SYSTEM	**FUNCTIONAL CHARACTERISTICS**
IRANS ISIS IVSAWS	5.4 Dynamic route change 6.2 Services/attractions directory 7.1 Roadway guidance sign information 7.2 Roadway notification sign information 7.3 Roadway regulatory sign information 7.4 CVO road restriction information 8.1 Immediate hazard warning

Cluster 3. This cluster summarizes some of the activities conducted by the regulatory and administrative agencies regarding trip planning and toll collection. In some ways, this cluster illustrates how IRANS could be used specifically by CVOs. Scenario Cl 1 was chosen as it included three of the functional characteristics that are organized into Cluster 3. In addition, Scenario Cl 1 was slightly modified to include regulatory enforcement, a function that had not been considered during the conceptualization of the commercial scenarios in Task B (see table 53).

Table 53. Description of Scenario C11.

PURPOSE	To illustrate a grouping of functiona l characteristics from Cluster 3 (5.1,52,5+7,9.3, and 9.41,
SUMMARY	An experienced interstate truck operator is passing between two States at nighttime. Prior to reaching the inspection point, her WIM system advises her to move to the right-hand lane, where her vehicle is weighed while traveling at normal speeds. Simultaneously, a sensor reads the truck's electronic credentials to validate safety records and debit the trucking company's account for road taxes. Finally, the driver's electronic credential are verified to ensure that her driver's license and permits are up to date and that her operating hours have been within the legal limits. The driver receives notification that all transactions have been performed successfully, and she proceeds at normal speed past the inspection point.
SYSTEM	**FUNCTIONAL CHARACTERISTICS**
IRANS CVO-SPECIFIC	5.7 Automatic toll collection 9.3 Regulatory administration 9.4 Regulatory enforcement

Cluster 5. Scenario C15 (see table 54) facilitates mainly the service directory and aid request. Most of the functions included in this cluster are related to IMSIS and IVSAWS. This cluster is important to consider as it represents two ATIS subsystems that support both the private and the commercial industries. Considering that the scenarios generated initially in Task B included, for the most part, a very limited number of functional characteristics, it was necessary to create a new scenario that would include more than one or two functions.

Table 54. Description of Scenario C15.

PURPOSE	To illustrate a grouping of functional characteristics from Cluster 5 (6.1, 6.2, 8.4, 8.5, and 8.6).
SUMMARY	An interstate truck operator is traveling on the interstate early Sunday morning. As he is driving, his "cargo/vehicle condition monitoring" informs him of a malfunction with one of the trailer's axles. The driver pulls over, checks it, and determines that help is needed. Using the ATIS, he selects a service station that is open at that time and requests their assistance.

SYSTEM	FUNCTIONAL CHARACTERISTICS
IMSIS IVSAWS	6.2 Services/attractions directory 8.4 Manual aid request 8.6 Cargo/vehicle condition monitoring

Commercial Driving Scenarios Based on the Nature of Task Interactions

The nature of task interactions remains the same whether or not the environment is private or commercial. In fact, regardless of whether the driver is operating in a private or a commercial vehicle, the order with which he or she will accomplish the various driving-related and ATIS-related tasks will not vary. In either case, some of the functions will interact in a sequential manner, while others will either branch out or be recursive. As a consequence, it seemed repetitive to create commercial driving scenarios that would illustrate each one of these interactions, especially considering that the above four scenarios summarized them. A similar conclusion was reached for the scenarios requiring high workload demands.